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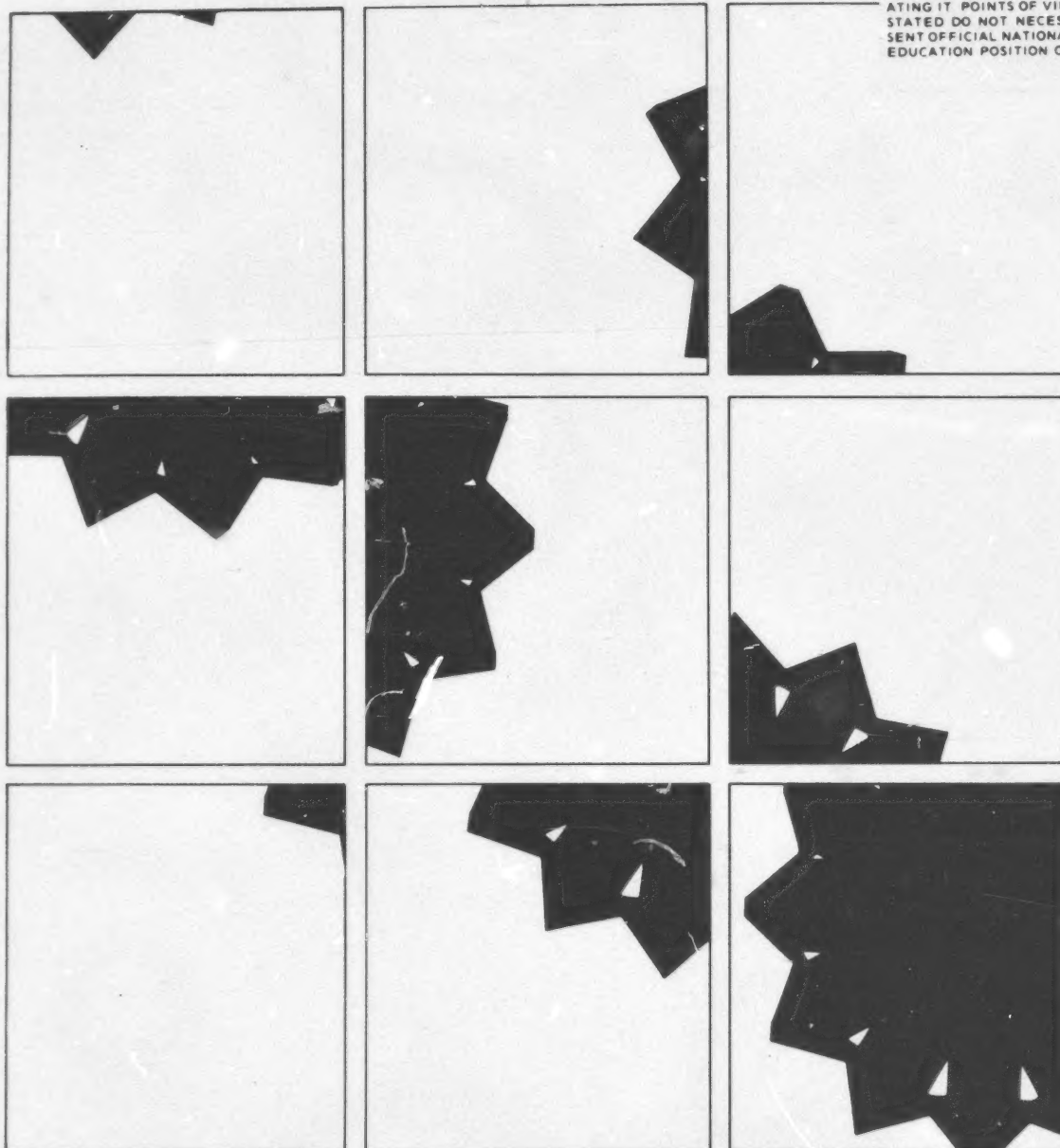
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ABSTRACT

By using a taxonomy of instructional strategy variables, an Instructional Strategy Diagnostic Profile (ISDP) was developed which can be used either to determine a judged index of instructional effectiveness for a previously designed instructional product or to guide the design and development of a new instructional product. Existing experimental research was examined to determine the empirical base underlying ISDP propositions relating student performance to parameter values on instructional strategy taxonomy variables. The following propositions or partial propositions were supported: (1) a segment of instruction should include all three of the primary presentation forms: rule, example, and practice; (2) the rule should be stated in other than verbal form or should be elaborated via an algorithm; (3) example displays should be elaborated via devices which focus the student's attention on the relevant attributes, and/or practice displays should provide explanatory feedback; (4) example or practice displays used alone would include nonexamples matched to examples on the basis of variable attributes; and (5) example and practice displays should include a divergent set of instances which range in difficulty. There is considerable empirical research support for most of the propositions underlying the ISDP, and it seems reasonable to predict that a given instructional package judged to have a high ISDP index should provide effective instruction. (Author/LBH)

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**RESEARCH SUPPORT FOR THE INSTRUCTIONAL
STRATEGY DIAGNOSTIC PROFILE**

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**Technical Report No. 3
March 15, 1976**

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SUMMARY

Problem

Merrill and his associates (Merrill & Boutwell, 1973; Merrill & Wood, 1974, Note 1) proposed a taxonomy of instructional strategy variables. Using the taxonomy variables, Merrill and Wood (1974, Note 1) developed an Instructional Strategy Diagnostic Profile (ISDP) which can be used to determine a judged index of instructional effectiveness for a previously designed instructional product or which can be used to guide the design and development of a new instructional product. The profile is based on a set of propositions relating student performance to parameter values on instructional strategy taxonomy variables. These underlying propositions have been derived primarily from applied instructional development experience and have not all been tested by carefully controlled experimental research. The problem for this investigation was to examine existing experimental research in an attempt to determine the empirical base for these propositions.

Objective

The purpose of this effort was to review existing research studies which investigated one or more of the propositions underlying the Instructional Strategy Diagnostic Profile.

Approach

Only a few studies have been purposely designed to test ISDP propositions. Furthermore, the vocabulary used by different investigators for the same variables varies considerably. The first step in our investigation was to carefully study the method sections of potentially relevant investigations in an attempt to reclassify the variables investigated in terms of the instructional strategy taxonomy. The reclassification enabled us to determine whether or not a given study tested some aspect of an ISDP proposition. Having selected a study for inclusion in our review, a second step was to transpose the dependent variable into a common dimension to facilitate comparison of the studies with each other. The data for a group of studies that tested some aspect of a given proposition were then plotted on a common graph to enable the reader of this review to directly compare the outcomes of the relevant studies. Based on these data, we determined those propositions which were supported and the implications for the ISDP.

Findings

Eight propositions were identified. Five of these received considerable support from the existing research, one received partial support, and no relevant studies could be identified for two of the propositions. The following propositions or partial propositions were supported: (1) A segment of instruction should include all three of the primary presentation forms: rule, example, and practice; (2) The rule should be stated in other than verbal form or should be elaborated via an algorithm; (3) Example displays should be elaborated via devices which focus the student's attention on the relevant attributes and/or practice displays should contain feedback which provides information as to why the student response was right or wrong in addition to right/wrong or correct answer information; (4) Example or practice displays, when used without the other, should include nonexamples which are matched to examples on the basis of variable attributes; and (5) Example and practice displays should include a divergent set of instances which range in difficulty. The following partial

proposition also received some minimal support: (6) A rule-practice sequence is superior to a practice-rule sequence. No studies investigating other sequence combinations were identified.

Conclusions

There is considerable empirical research support for most of the propositions underlying the Instructional Strategy Diagnostic Profile. While there were occasional studies which showed no differences between particular treatments there were no contradictory findings. There are some aspects of the profile, particularly those dealing with learner control, which have not been investigated and consequently are as yet unproved.

It seems reasonable to predict that a given instructional package which is judged to have a high ISDP index should provide rather effective instruction. In other words, there should be a high correlation between student performance and the ISDP index. Furthermore, a new instructional development effort which uses the ISDP as a design guide should result in more effective instruction than would be the case were the design based on intuition or some other methodology.

TABLE OF CONTENTS

	Page
SUMMARY	1
LIST OF ILLUSTRATIONS	4
INTRODUCTION	5
A PROPOSED TAXONOMY OF INSTRUCTIONAL STRATEGY VARIABLES	6
THE INSTRUCTIONAL STRATEGY DIAGNOSTIC PROFILE	11
RESULTS	14
CONCLUSIONS AND RECOMMENDATIONS	37
REFERENCE NOTES	39
REFERENCES	40

LIST OF ILLUSTRATIONS

	Page
Figure 1. Components of subject matter	6
Figure 2. Classification of objectives	8
Figure 3. Primary presentation forms	9
Figure 4. The instructional strategy diagnostic profile	13
Figure 5. Investigations including treatment comparisons relevant to the primary presentation forms hypothesis	15
Figure 6. Comparisons of primary presentation forms with control groups	17
Figure 7a. Comparisons of primary presentation forms with one another	18
Figure 7b. Comparisons of primary presentation forms with one another	19
Figure 8. Investigations including treatment comparisons relevant to the primary presentation forms sequence hypothesis	21
Figure 9. Comparisons of primary presentation forms sequence	22
Figure 10. Investigations including treatment comparisons relevant to the generality representation hypothesis	24
Figure 11. Comparisons of rule (EG) with rules plus iconic or algorithmic representations	25
Figure 12. Investigations including treatment comparisons relevant to the Mathemagenic Information hypothesis	28
Figure 13. Student performance comparisons of Eeg or leg treatments plus attribute isolation or algorithmic mathemagenic information	29
Figure 14. Time on task comparisons of Eeg or leg treatments plus attribute isolation or algorithmic mathemagenic information	30
Figure 15. Investigations including treatment comparisons relevant to the attribute matching hypothesis	32
Figure 16. Comparisons of Eeg or leg displays with and without attribute matching	33
Figure 17a. Investigations including treatment comparisons relevant to the instance sampling hypothesis--divergence	35
Figure 17b. Instance sampling hypothesis--difficulty	35
Figure 18. Comparisons of Eeg or leg displays where subsequent instances are divergent and convergent and where instances range in difficulty and are all easy	36

INTRODUCTION

Problem and Background

Results of educational research commonly show no significant differences. Thus, much of our educational practice is unsupported by an unequivocal or even adequate research base. At least one reason for this state of affairs is that the components of the instructional situation selected for analysis are either inappropriately selected or represent too high a level of generality to enter into meaningful propositions concerning the instructional process. The situation is complicated still further because each investigator either tends to use an esoteric vocabulary which is difficult to relate to the work of other investigators or uses familiar variables in ways inconsistent with their previous use. Furthermore, the variables selected in one situation often are at a different level of abstraction from the variables used in a related situation. Progress in developing adequate instructional theory will be considerably facilitated by the development of an internally consistent taxonomy of variables which can be demonstrated to enter into meaningful and consistent propositions (Snow, 1973).

A taxonomy of instructional strategy variables was previously proposed (Merrill and Boutwell, 1973; Merrill and Wood, 1974, Note 1). This taxonomy defines the components of subject matter content, a two-way classification of objectives on content type and response condition dimensions, four primary presentation forms, types of representation, and types of instructional help (Mathematical information). An Instructional Strategy Diagnostic Profile is under development and investigation (Merrill and Wood, Note 2). This profile consists of an instrument which enables the user to determine a judged index of instructional effectiveness for a previously designed instructional product. This profile is based on a set of propositions which relates parameter values on the instructional strategy taxonomy variables and measures of student performance.

Purpose

The objective of this effort was to review existing research studies which investigated one or more of the propositions underlying the Instructional Strategy Diagnostic Profile. Our intent was to classify the variables investigated in terms of the Merrill and Wood taxonomy and to isolate those treatment comparisons which tested aspects of the propositions on which the profile is based. Further, it was our intent to transpose the dependent variables, where possible, into a common dimension to facilitate comparison of the results from study to study. Finally, based on the studies reviewed our goal was to conclude this report with recommendations for additional research and to emphasize applications of the Instructional Strategy Diagnostic Profile to current instructional development practice which seem justified by our findings.

A PROPOSED TAXONOMY OF INSTRUCTIONAL STRATEGY VARIABLES

Primary Components

Merrill and Boutwell (1973) attempted to identify a taxonomy of instructional strategy variables which seemed to be meaningful for concept classification and rule using tasks. Merrill and Wood (1974, Note 1) subsequently refined and extended this instructional strategy taxonomy with the view that "cognitive subject matter is created when the objects and events comprising some part of our real or imagined environment are organized into categories and the relationship between these categories has been identified and described via language or some other symbol system." The taxonomy suggests that the following terms be used to identify the primary components of cognitive subject matter.

1. Referent. A referent is an object, event, or symbol which exists, or could exist, in our real or imagined environment.
2. Concept. A concept is created when a set of referents--objects, events, or symbols--are grouped together because they share some common characteristics and are referenced by a particular name or label.
3. Operation. An operation is an event concept which indicates the relationship between two or more other concepts.
4. Domain and Range Concepts. Domain concepts are those classes of referents upon which the operation acts or to which the operation is applied. Range concepts are those classes of referents which result from the application of the operation.
5. Rule. A rule is an ordered relation consisting of a set of domain concepts, one or more operations, and a set of range concepts.

Figure 1 illustrates the interrelationship of each of these components.

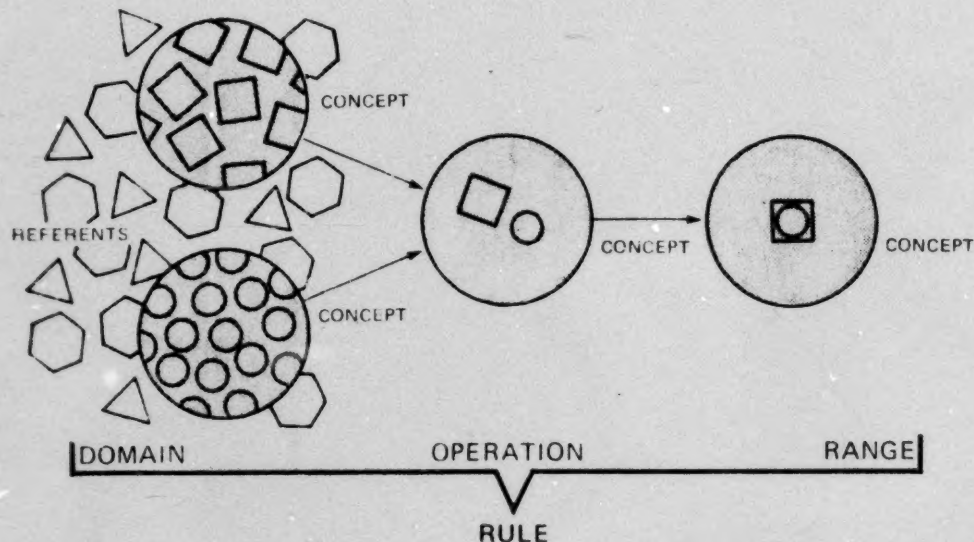


Figure 1. Components of subject matter.

Classification of Objectives

The taxonomy indicates that (1) the conditions for responding and the type of content operation are somewhat independent and (2) objectives are defined by combining a particular response condition with a given type of content operation. Three types of content operations are defined:

1. Identity (ID). The referents of the domain concept are associated on a one-to-one basis with the referents of the range concept.
2. Descriptive (D). The referents of the range concept are described by logical combination of instances of two or more domain concepts. A rule which involves a descriptive operation is called a definition.
3. Productive (P). The referents of the range concept are produced by composition, decomposition, or some other combination operation in which referents of the domain concepts are qualitatively changed as they are combined to produce referents of the range concept. A rule which involves a productive operation is called a proposition.

Three levels of response conditions are also defined:

1. Rule Remembering (RR). Rule remembering can be inferred when, given a set of identity pairs, the student is asked to recall or recognize one member of the pair given the other or when a student is asked to recognize or recall a specific definition or proposition.
2. Rule Using (RU). Rule using can be inferred when, given unencountered instances of each of the domain concepts and the operation, the student is able to produce or identify the resulting instance(s) of the range concept(s).
3. Rule Finding (RF). Rule finding can be inferred when, given labels and unencountered instances of the domain concepts and range concepts, the student is able to find or invent an operation that will complete the ordered relationship between the domain and range.

Figure 2 illustrates the resulting two-way classification matrix.

RESPONSE CONDITIONS	Rule Finding		Find a descriptive operation	Find a productive operation
	Rule Using		Use a descriptive operation (Classification)	Use a productive operation
	Rule Remembering	Remember an identity	Remember a definition	Remember a proposition
		Identity	Descriptive (Definition)	Productive (Proposition)
CONTENT OPERATION				

Figure 2. Classification of objectives

Primary Presentation Forms

The taxonomy suggests that the basis of an instructional strategy is a series of displays, each of which can be characterized as one of four primary presentation forms. These forms represent both the general and specific manner in which cognitive rules (definitions or propositions) can be presented. They also illustrate a consistent distinction between content and response modes. The two content modes are defined as follows:

1. Generality (G). For a definition, a generality is a statement identifying each of the critical characteristics (attributes) and indicating how these attributes are combined. For a proposition, a generality is the identification of the domain concepts, the range concepts, and the operation(s) by which instances of the domain are combined or modified to produce instance(s) of the range.
2. Instance (eq). For a definition, an instance is a particular object, event or symbol from the class or a high fidelity representation of a particular referent. For a proposition, an instance is a referent or its representation from each of the domain concepts, the operation as applied or to be applied to these referents, and identification of the resulting instance of the range concept(s).

As indicated, generalities or instances can also be presented in a "tell" or "ask" type of response mode. The two response modes are defined as follows:

1. Expository (E). If the primary purpose of the display is to present either a rule or to illustrate its use with an instance, it is said to be an expository presentation.
2. Inquisitory (I). If the primary purpose of the display is to require the student to remember or use the rule, it is said to be an inquisitory presentation.

The four primary presentation forms can be combined into the 2x2 matrix illustrated in Figure 3. "Rule," "recall," "example," and "practice" are shorthand substitutes for expository generality (EG), inquisitory generality (IG), expository instance (Eeg) and inquisitory instance (leg) respectively and when used in the context of the taxonomy should be used with the precise connotations of these terms.

		HOW WAS IT PRESENTED?	
		EXPOSITORY	INQUISITORY
WHAT IS PRESENTED?	GENERALITY	EG "RULE"	IG "RECALL"
	INSTANCE	Eeg "EXAMPLE"	leg "PRACTICE"

Figure 3. Primary presentation forms

Types of Representation

Another characteristic of a display is the form of representation used. These levels of representation are defined as follows:

1. Enactive (O). When the display presents the referent itself in such a way that the student can manipulate the attributes of the actual objects or events involved, the representation is said to be enactive.
2. Iconic (P). When the referents for a particular concept or rule are represented by some graphic or symbolic representation such that the critical attributes are somewhat isomorphic with the referent, then the representation is said to be iconic.
3. Symbolic (S). When referents or the relationship between referents are represented via language or some other symbol system such that the attributes are no longer isomorphic, the representation is said to be symbolic.

Instructional Help

Primary presentation forms are often augmented with mathemagenic information to directly or indirectly facilitate a learner's processing of the content information. Mathemagenic information has two forms: (1) Prompting, which is added to a display presented prior to the student's response, and (2) Feedback, which is added to a student's response to indicate its correctness and why it was correct or incorrect.

Several types of mathemagenic information can be defined as follows:

1. None (NO). Unlike each of the other display variables described thus far which must take some value other than zero in every display, mathemagenic prompting may or may not be present. When no facilitating directions or information is provided with a given display, this variable is coded "NO."
2. Right/Wrong Knowledge of Results (r/w). This is merely the message that the student's response was right or wrong without additional information.
3. Correct Answer Knowledge of Results (ca). The problem is worked out showing the correct answer. Correct answer knowledge of results may be provided with or without right/wrong knowledge of results.
4. Mnemonic (mn). A mnemonic is some form of memory aid thought to facilitate later recall of specific information.
5. Attribute Isolation (ai). Attribute isolation is the use of attention-focusing devices designed to call the student's attention to the attributes of a concept.
6. Algorithm (al). An algorithm might be defined as a rule for using a rule. Usually an algorithm is a step-by-step analysis of the process involved in identifying instances of a given concept or in finding the instances of the range concept(s) in a given rule using task.
7. Heuristic (he). A heuristic consists of an incomplete algorithm. It gives the student hints for some useful procedures to try.

THE INSTRUCTIONAL STRATEGY DIAGNOSTIC PROFILE

Defining a taxonomy of instructional strategy variables is merely an academic exercise unless the concepts defined enter into meaningful propositions which can be or are supported by empirical data. The Instructional Strategy Diagnostic Profile (ISDP) is an attempt to identify an integrated set of propositions stating the hypothesized relationships between parameter values on the taxonomy strategy variables and student performance. By stating these propositions in question form and defining conventions for assigning index values for various questions or sets of questions, one can determine a set of strategy indices for a given segment of already designed and developed instruction. These indices should reflect the instruction's effectiveness and efficiency, if the proposed relationships are in fact supported by empirical data.

Stated generally and without qualifications and limitations, the Instructional Strategy Diagnostic Profile is based on the following propositions:

1. Primary Presentation Forms. A segment of instruction should include all three of the primary presentation forms: rule (EG), example (Eeg), and practice (Ieg). A segment is defined as that instruction designed to teach a given descriptive or productive rule or coordinate set of such rules.
2. Primary Presentation Form Sequence. The primary presentation forms for a given segment of instruction should be sequenced in some variation of rule-example-practice. Acceptable variations include the use of a reference example simultaneous with or previous to the presentation of the rule. Such presentations should include additional examples following the presentation of the rule.
3. Primary Presentation Form Isolation. The primary presentation forms for a given segment of instruction and accompanying elaboration should be identified and isolated in such a way that a student can easily locate, skip, or review a given form.
4. Learner Control. The student should be able to alter his primary presentation form sequence by returning at will to previously presented forms after having studied subsequent displays. In other words, the student should be able to return to the rule after studying an example or practice display, skip to a practice display before studying the rule, etc.
5. Generality Representation. The rule should be restated, represented in other than verbal form, and/or elaborated via a mnemonic or an algorithm.
6. Mathemagenic Information. Example displays should be elaborated via mathemagenic information prompting or simplified representation. Practice displays should include mathemagenic information or simplified representation feedback in addition to correct answer or right/wrong knowledge of results.
7. Attribute Matching. Example displays should include matched nonexamples. Practice displays should be randomly sequenced and unmatched to nonexamples.
8. Instance Sampling. Instances in both example and practice displays should be divergent, range in difficulty, and/or include a variety of representation forms.

In the above propositions, the word should implies that if the relationship is completely implemented by the instructional strategy then (1) student achievement, as defined by errors on the test (see below), will be better; (2) student efficiency, as defined by time to criterion, will be less; and (3) student affect, as described by self report of satisfaction, will be more positive than when the relationship specified by the proposition is partially implemented.

The ISDP propositions assume an adequate descriptive or productive "rule using" test. An adequate test is one constructed from previously "unencountered" instances of the rule domain where the instances used are represented in such a way that all of the critical attributes are available to the student. For reliability the test should contain several instances for each rule tested. Test items should be free of "mathemagenic information prompting," and should not be followed by "mathemagenic information feedback." Instances should be "unmatched," "divergent," and randomly sequenced. A variety of representations forms should be used.

Most existing tests do not meet all of these conditions. The above propositions assume that the test does meet all or most of these conditions. The ISDP includes a test adequacy index (see Figure 4) to reflect the degree to which a given test meets these conditions.

Figure 4 is the question form of the ISDP. Each section represents the application of the propositions to a given primary presentation form component of a specific segment of instruction. The numbers in the middle of the page indicate the procedure for determining the index. In the current version of the ISDP some of the propositions are combined as indicated. The "and" or "or" notation indicates the logical combination of the questions necessary in order to score a point. For example, under EG both questions 1 and 2 must be answered affirmatively before the index is incremented by 1. If the answer to any of the questions 5, 6, 7, or 8 is "yes," the index is incremented by 1 for the third section under EG. Details concerning procedures for dividing instruction into segments, conventions for deciding difficult cases, and illustrations of the application of the profile are described elsewhere (Merrill and Wood, Note 2) and are beyond the scope of this paper.

EG	YES	NO	Eeg
1. Is there an EG for relation X?	"AND"	"AND"	1. Are there Eeg's for relation X?
2. Is EG complete and concise?	1 0	1 0	2. Are critical attributes adequately represented?
3. Is EG separate and identified?	"AND"	"AND"	3. Are Eeg's separate and identified?
4. Is EG elaboration separate and identified?	1 0	1 0	4. Is Eeg elaboration separate and identified?
5. Is there an equivalent restatement of EG?	"OR"	"OR"	5. Does Eeg elaboration include mathemagenic information?
6. Is EG represented in other than verbal form?	1 0	1 0	6. Is each Eeg matched with a non-example?
7. Does EG elaboration include algorithm?	1 0	1 0	7. Do early Eeg's use simplified representation?
8. Does EG elaboration include a mnemonic?			8. Are Eeg's divergent?
			9. Do Eeg's include a range of difficulty?
			10. Do Eeg's use a variety of representation?

leg	YES	NO	TEST
1. Are there leg's for relation X?	"AND"	"AND"	1. Does the test consist of leg displays?
2. Are critical attributes adequately represented?	1 0	1 0	2. Are critical attributes adequately represented?
3. Are only unencountered instances used?	"AND"	"AND"	3. Are only unencountered instances used?
4. Is K of R or feedback included?	1 0	1 0	4. Are 5 + 3 instances included for each relation?
5. Are leg's separate and clearly identified?	"AND"	"AND"	5. Are test items free of prompting?
6. Is feedback separate and clearly identified?	1 0	1 0	6. Are test items free of ca, K of R, or feedback?
7. Does feedback include mathemagenic information?	"AND"	"AND"	7. Are test items unmatched?
8. Are leg's without mathemagenic prompting?	1 0	1 0	8. Are test items sequenced randomly?
9. Are leg's unmatched?	"OR"	"OR"	9. Are the test items divergent?
10. Are leg's divergent?	1 0	1 0	10. Is a range of difficulty included?
11. Do leg's include a range of difficulty?			11. Are a variety of representation forms used?
12. Do leg's use a variety of representation?			

Figure 4. The instructional strategy diagnostic profile.

RESULTS

As indicated previously the purpose of this paper is to review existing research studies which test the ISDP propositions. It should be noted that many of these investigations were designed to test hypotheses often unrelated to the ISDP. In fact only a few of the studies reviewed were purposely designed to test these propositions or correlaries of these propositions. Since the vocabulary used by the different investigators varies considerably, it was necessary to study carefully the method sections of the research reports in an attempt to reclassify the treatments involved in terms of the taxonomy. Having made this classification, we could then determine whether or not the investigation tested some aspect of the ISDP propositions. In many cases only some of the treatments provided a test of the ISDP hypotheses. Other comparisons in these studies were irrelevant to the ISDP. We have included only these comparisons which are relevant.

Only studies in which the posttest required rule using (for either descriptive or productive operations) were included. Tests often did not meet all of the test conditions specified above. As far as we could determine from the reports, however, the test in each of the studies reviewed involved at least descriptive or productive rule using for several unencountered examples.

For each hypothesis this review includes one figure which indicates, across the top, possible or representative treatment conditions, and which identifies, down the left side, those studies which compared two or more of these treatments. (See Figures 5, 8, 10, 12, 15, 17.) The treatments included in a given study are indicated by an "x" in the body of the table. The type of task, concept classification (descriptive rule using) or rule using (productive rule using), and the age of the students in the sample are indicated for each study. Unless otherwise indicated, a control treatment consists of a group of students who received some placebo task unrelated to the content in the experimental treatments.

A second figure (or figures) for each hypothesis illustrates the percent correct on the posttest for each of the treatments in each study. (See Figures 6, 7, 9, 11, 13, 14, 16, 18.) In most cases the percent correct was available or could be determined from the data reported. Where this information was not available, the relative relationship of the treatments being compared was plotted but arbitrarily positioned on the ordinate axis as indicated in the notes. The dotted and solid lines connecting treatments have no meaning except to connect similar treatment conditions across the several studies and thus to facilitate your examination of the data.

Primary Presentation Forms

The primary presentation form hypothesis states that a segment of instruction should consist of the three primary presentation forms: rule (EG), example (Eeg), and practice (leg). A segment is defined as instruction for a given descriptive or productive relationship or a coordinate set of such relationships. Figure 5 identifies the twenty (20) studies reviewed for this hypothesis. Only Klausmeier and Feldman (1975), Merrill and Tennyson (1971), and Smith (Note 3), however, were designed as direct tests. The other studies included one or more of the treatments indicated in Figure 5, while testing other hypotheses.

As indicated across the top of Figure 5, eight treatment conditions are of interest. These treatments may have included a single rule or a set of rules and may have involved a single example or several examples for a given rule. In some treatments, the examples may have been matched with nonexamples. If an leg (practice) treatment did not include at least right/wrong or correct/answer feedback, it was not included (e.g., Smith, Note 3, included two such pseudo-practice treatments which were not included).

TREATMENT CONDITIONS

	Control	EG (Rule)	Eeg (Example)	leg (Practice)	EG Eeg (Rule Example)	EG leg (Rule Practice)	Eeg leg (Example Practice)	EG Eeg leg (Rule Example Practice)	Task	Sample
Anderson & Kulhavy (1972)		X				X			Concept Classification	College
Cole & Raven (1969)	X		X		X				Rule Using	12-13 years
Deno, Jenkins & Marsey (1971)	X			X		X			Concept Classification	College
Danks & Gans (1975)	X					X			Rule Using	College
Guthrie (1967)	X			X		X			Rule Using	College
Guthrie & Baldwin (1970)	X	X				X			Concept Classification	11-12 years
Hammond & Raven (1973)	X							X	Rule Using	13-14 years
Johnson (1968)	X		X				X		Concept Classification	College
Kalish, Merrill, Towle & Steve (Note 5)			X		X				Rule Using	College
Klausmeier & Feldman (1975)	X	X	X		X ₁ X ₂				Concept Classification	9-10 years
Merrill (1974)			X		X				Rule Using	College
Merrill & Tennyson (Note 4)	X	X	X		X				Concept Classification	College
Raven (1970)	X							X	Concept Classification	8-9 years
Scandura, Woodward & Lee (1967)	X		X		X				Rule Finding	College
Scandura (1974)	X					X			Rule Using	5-9 years
Smith (Note 3)	X	X			X			X	Rule Using	College Students
Stern & Keislar (1967)	X			X		X			Rule Finding	8-9 years
Tanner (1969)	X			X		X			Rule Using	13-14 years
Williams & Levy (1964)			X	X					Concept Classification	11-12 years
Yelon & Schmidt (1973)	X	X							Rule Using	College

Figure 5. Investigations including treatment comparisons relevant to the primary presentation forms hypothesis.

Figures 6 and 7 illustrate data for the possible pairwise comparisons of the primary presentation forms. When a study contained 3 or more groups, a given treatment is plotted several times to show its relationship to each of the other treatments. Figure 6 is a comparison of control versus all other treatments. Figure 7 is divided into six sections from left to right as follows: EG (rule) vs. all remaining treatments; Eeg (example) vs. all remaining treatments, etc. All possible combinations are indicated along the abscissa axis. As indicated, some of the comparisons have not been investigated by the studies reviewed.

As might be expected, every combination of primary presentation form was demonstrated to be superior to control treatments. There were five (5) cases (Guthrie, 1967; Guthrie & Baldwin, 1970; Johnson, 1968; Smith, Note 3, Stern & Keislar, 1967) where EG, Eeg, leg, and EG-Eeg treatments were not significantly different from the control (see Figure 6).

Two studies (Klausmeier & Feldman, 1975; Merrill & Tenny on, Note 4) failed to demonstrate a difference between rule alone (EG) and example alone (Eeg) presentations (see Figure 7a). This suggests that presenting examples may be equivalent to presenting a rule. No one compared practice alone (leg) vs. rule alone (EG) presentations. Except for the presentation of a single example set with the rule (Klausmeier & Feldman, 1975) and a rule-example presentation for high IQ students (Guthrie & Baldwin, 1970), all the combinations of two or more presentation forms investigated were superior to presenting the rule alone.

In one study practice alone (leg) was superior to examples alone (Eeg) (Williams & Levy, 1964). With one exception (Klausmeier & Feldman, 1975) all the combinations of two or more presentation forms investigated were superior to presenting examples alone.

Four (4) studies compared practice alone (leg) with rule plus practice (EG-leg). The Tanner (1969) study showed that rule plus practice (EG-leg) was not significantly better than practice alone (leg). The other three studies suggest that rule plus practice is superior to practice alone (leg). The procedures in the Tanner (1969) study were difficult to determine. It may be that the practice test did not meet the criterion specified. Hence, the Tanner (1969) study should probably be discounted somewhat. We were unable to locate comparisons of practice alone with any other primary presentation form combinations.

The only other comparison available (Smith, Note 3) demonstrated that a rule-example-practice presentation (EG-Eeg-leg) was superior to a rule-example (EG-Eeg) presentation with no practice.

Additional research on the primary presentation form hypothesis would be desirable. The relative contribution of practice, especially, needs to be investigated. Figure 7 indicates those treatments comparisons for which the reviewers have been unable to find relevant data.

Based on the available data, the primary presentation form hypothesis does seem to be supported for student performance. Too few of the studies reported efficiency or affective data to enable us to make meaningful comparisons. The following correlaries are also suggested by the data: (a) practice alone is superior to examples alone; (b) while there is no direct data, it seems reasonable to hypothesize that practice alone is probably superior to rule alone; (c) rule alone and examples alone seem to make equivalent contributions; (d) any combination of two or more presentation forms is superior to any presentation form alone; and (e) the superiority of a combination of all three forms over any combination of only two primary presentation forms received only limited support, but it seems reasonable to hypothesize that all three forms will be superior to any combination of only two forms.

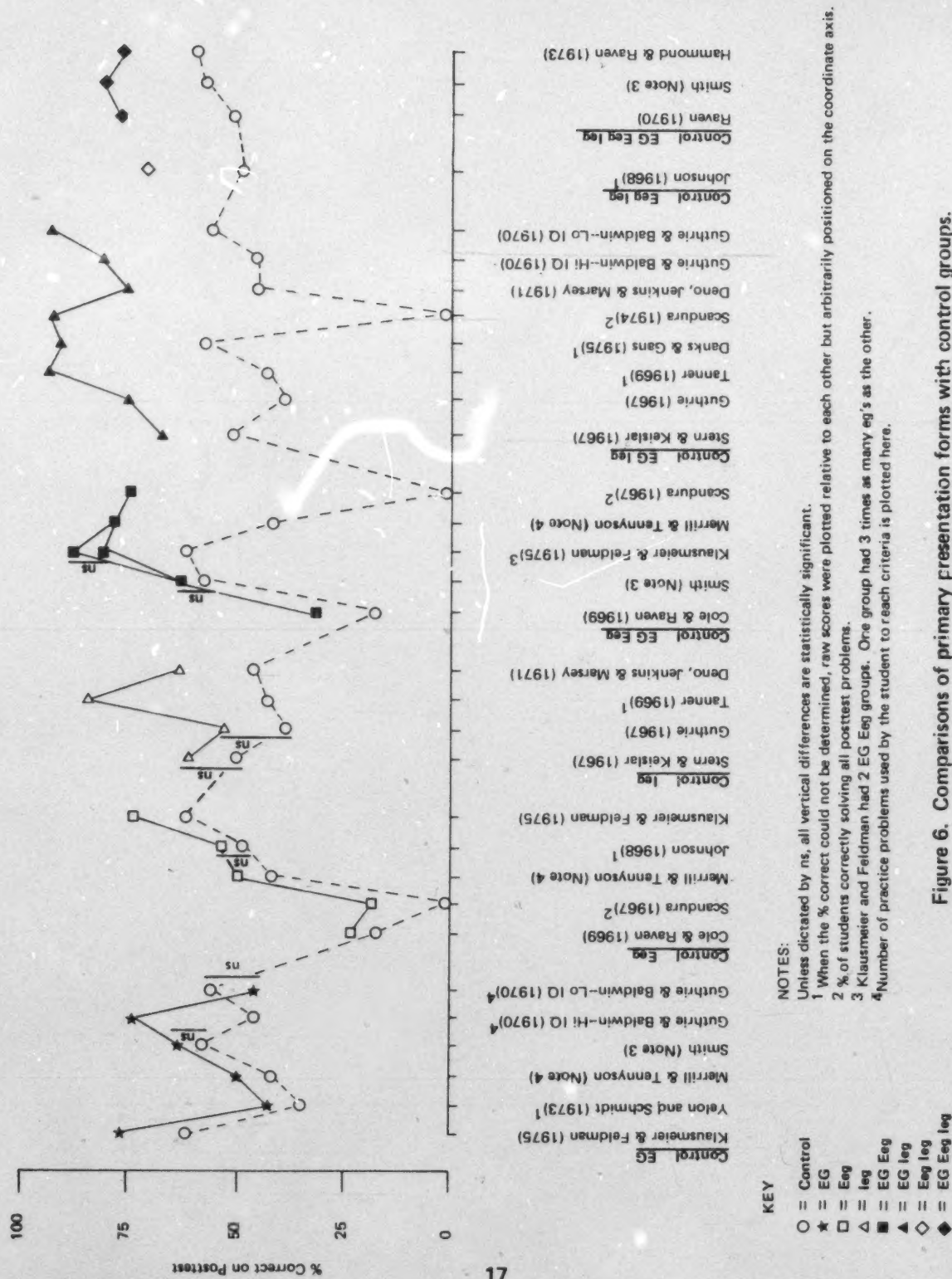


Figure 6. Comparisons of primary presentation forms with control groups.

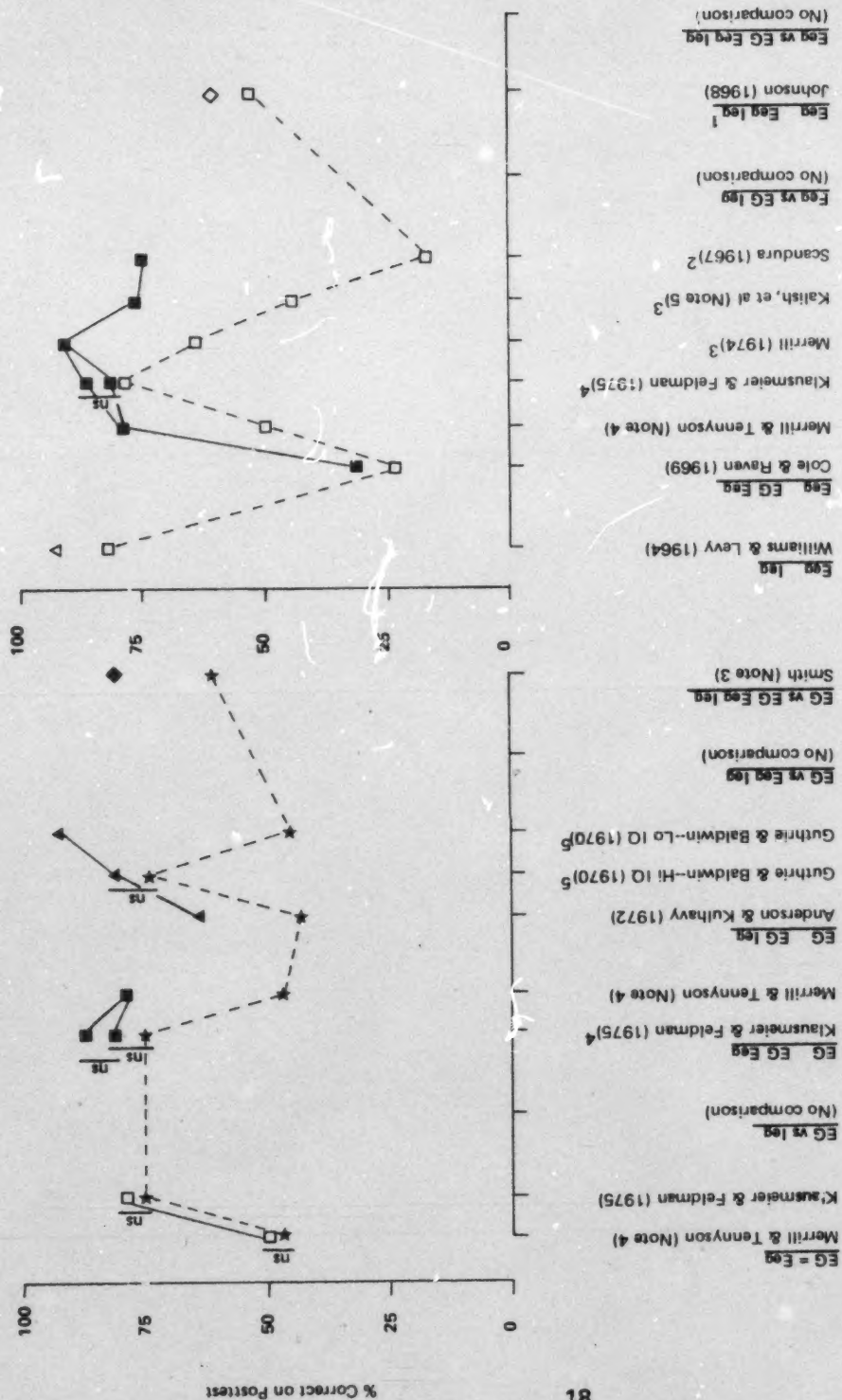


Figure 7a. Comparisons of primary presentation forms with one another.

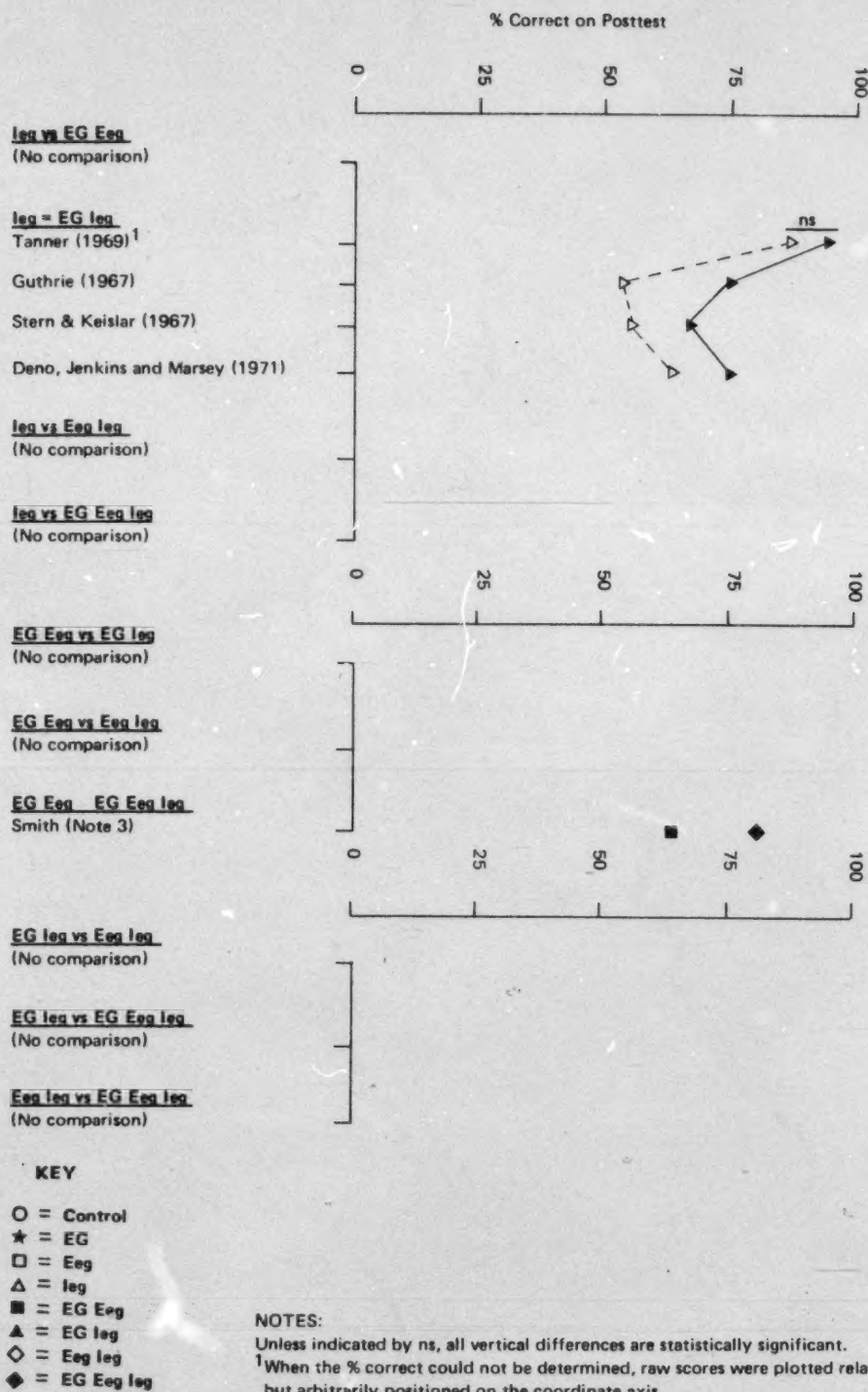


Figure 7b. Comparisons of primary presentation forms with one another.

Primary Presentation Form Sequence

The primary presentation form sequence hypothesis states that the primary presentation forms within a given segment of instruction should be sequenced in some variation of rule-example-practice (EG-Eeg-leg). Six (6) studies have been identified which directly test some aspects of this hypothesis. All of these studies involved rule (EG) and practice (leg). No studies were found which involved sequence of rule (EG), and example (Eeg) or the sequence of all three forms, rule (EG), example (Eeg), and practice (leg). Some of the more obvious sequence treatments are indicated across the top of Figure 8. By repeating a given primary presentation more than once it should be obvious that many other combinations are possible. Figure 8 identifies the six (6) studies reviewed for this hypothesis.

Figure 9 illustrates the sequence comparisons for each study. Three studies (Danks & Gans, 1975; Guthrie, 1967; Worthen, 1968) demonstrated that a rule-practice (EG-leg) sequence was superior to a practice-rule (leg-EG) sequence. However, three other studies (Dossey & Henderson, 1974; Koran, 1971; Krumboltz & Yabroff, 1965) found no difference in these two sequences. Worthen (1968) found the practice-rule (leg-EG) sequence to be more effective on a five (5) week retention test. Dossey and Henderson (1974) found that a rule practice-rule (EG-leg-EG) treatment was superior to a practice-rule-practice (leg-EG-leg) treatment. In both the Danks and Gans (1975) and Dossey and Henderson (1974) studies no difference was detected between practice-rule-practice (leg-EG-leg) and rule-practice (EG-leg) treatments. However, Danks and Gans (1975) found a practice-rule-practice (leg-EG-leg) treatment to be superior to a practice-rule (leg-EG) treatment while Dossey and Henderson (1974) did not.

Care must be taken in interpreting the results reported here. Because we must extrapolate from the treatment descriptions provided in the experimental reports to the variables as defined for the strategy profile, there is considerable margin for misinterpretation. The Guthrie (1967) study is the only one of the six in which the description is sufficiently detailed to enable the reviewers to state with confidence that the displays involved in the treatments adequately represented rule (EG) and practice (leg) displays as defined. The Worthen (1968) study involved eight teachers in actual classrooms with the same teachers implementing each treatment with different classes. It is not only possible, but likely, that the treatments shared many common elements. It is also likely that it is these linked variables, such as the type of guidance given, rather than the sequence of primary presentation forms, which accounted for the small differences detected. In the Krumboltz and Yabroff (1965) study and the Koran (1971) replication the treatments were delivered via programmed instruction. While the authors referred to "example" and "rule" displays it is very likely that they were example-like and rule-like rather than implementing all of the characteristics of such displays as defined by the Merrill and Wood (Note 2) taxonomy. Consequently, conclusions about primary presentation form sequence based on these studies must be tentative at best.

The authors considered a number of studies on sequence in programmed instruction for inclusion in this review. (See Cartwright, 1971; Payne, Krathwohl & Gordon, 1967; Pyatte, 1969.) All of these studies compared ordered versus scrambled sequence of frames and hence did not represent systematic comparisons of the sequence treatments specified. Furthermore, most used a memory level rather than a rule using test. And, finally the frames used as the basic unit for sequence did not correspond to rule (EG) and practice (leg) displays as defined. In every case there were no significant differences between treatment groups.

As with the first hypothesis most studies did not include time or attitude data.

Primary Presentation Form Isolation

The isolation hypothesis states that the primary presentation forms for a given segment of instruction and the accompanying elaboration should be identified and isolated in such a way that a student can easily locate, skip, or review a given form. No studies were identified which directly investigated this proposition. Merrill (1975) suggested that this procedure would enable the student to adapt the instruction to himself and thus optimize the presentation for his own personal "momentary aptitude state." This proposition is one of the primary strategy mechanisms for enabling a given strategy to handle a wide range of individual differences. It is predicted that the amount of variance which can be attributed to individual differences is inversely proportional to the degree to which the isolation proposition is implemented within a given strategy. This hypothesis has yet to be investigated in an experimental setting.

Learner Control

The learner control hypothesis states that the student should be able to alter his primary presentation form sequence by returning at will to previously presented forms after having studied subsequent displays. No studies were identified which directly tested this hypothesis. The term, learner control, has been used in studies of content sequence, amount of practice, and content selection but, as yet, not in terms of learner control of strategy. The learner control hypothesis is also believed to enable a given strategy to accommodate a wide range of individual differences by enabling the student to select those display forms which are most consistent with his instructional needs at a given moment in time.

Generality Representation

The generality representation hypothesis states that the rule (EG) should be restated, represented in other than verbal form, and/or elaborated via a mnemonic or an algorithm. Four studies have been identified which directly test some aspect of this hypothesis. Three of these studies investigated the addition of iconic representations to a verbal generality. One study investigated the addition of algorithmic elaboration to the generality. Some of the possible generality representation treatments are indicated across the top of Figure 10. Other combinations should occur to the reader. Figure 10 identifies the treatments included in each of the four (4) studies reviewed.

Figure 11 indicates the posttest performance resulting from the various treatments. Three studies (Austin, 1974; Holliday, 1975; Weisberg, 1970) demonstrated that test performance improves when iconic representations are added to verbal generalities. The Austin (1974) study seems to indicate that, for college students, observing an iconic demonstration is as effective as performing the actual manipulation themselves. In the Weisberg (1970) study the junior high school students who were given only the verbal rule statement (EG) did no better than the controls.

Osguthorpe (1975) used a factorial design in which one dimension included either no rule (control), a verbal rule (EG_V), or the verbal rule plus algorithmic elaboration (EG_{ALG}). A second dimension included either no practice (No leg), practice with right/wrong feedback (leg + r/w FB), or practice with algorithmic feedback (leg + algorithmic FB). The addition of algorithmic elaboration to the generality results in a performance increment whether or not practice items are included. However, adding algorithmic feedback to the practice seems to be equivalent to the addition of algorithmic elaboration to the generality; consequently, there is not an additional performance increment when both are used together.

Based on the studies reviewed the generality representation hypothesis does seem to be supported for student performance. None of the studies reported efficiency or affective data. No studies were identified which investigated restating the generality or elaborating via mnemonic information.

	Control (no EG)	EG (verbal)	EG + (verbal restatement)	EG + iconic representation	EG + iconic + enactive representation	EGALG + heuristic	EGV + EGALG	EG _{mnemonic}	EGV + EG _{mnemonic}	Task	Sample
Austin (1974)		X		X	X					Rule Using	College
Holliday (1975)		X		X						Rule Using	15-16 years
Osguthorpe (1975)	X	X					X X			Concept Classification	College

Figure 10. Investigations including treatment comparisons relevant to the generality representation hypothesis.

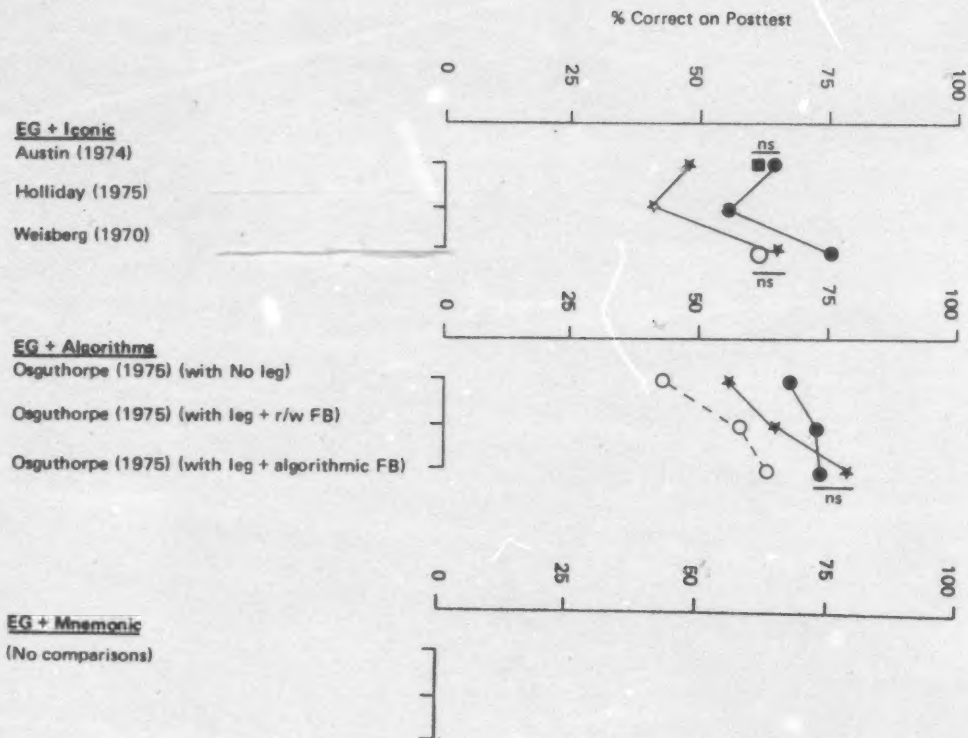


Figure 11. Comparisons of rule (EG) with rules plus iconic or algorithmic representations.

Mathemagenic Information

The mathemagenic information hypothesis states that example (Eeg) displays should be elaborated via mathemagenic information prompting or simplified representation and that practice (leg) displays should include mathemagenic information or simplified representation feedback in addition to correct answer or right/wrong knowledge of results. A number of studies were identified which compared visual versus symbolic representation (cf. Klum, Lewis, Omari, & Cook, 1974) or various types of visual presentation (cf. Dwyer, 1968) however, these studies did not compare example or practice displays with and without visual or simplified representation as specified by the hypothesis and are consequently not included in this review. There have been numerous studies contrasting correct answer or right/wrong feedback with no feedback. It has been rather firmly established that feedback facilitates performance. Since the mathemagenic information hypothesis is concerned with the effect of information in addition to right/wrong or correct answer, none of these studies were included in this review. Gilman (1969) showed that correct answer feedback (ca) was superior to only right/wrong information (r/w). Since our hypothesis is concerned primarily with information in addition to ca or r/w, data from his study is not included in Figure 13.

Figure 12 indicates treatments which involve example displays (Eeg) or practice displays (leg) to which either attribute isolation or algorithmic prompting or feedback has or has not been added. It is possible, of course, to produce innumerable variations of these basic displays. The most frequent variation is the addition of other primary presentation forms to the strategy-rule displays (EG), example displays (Eeg) when the variation in treatment is on the practice (leg), or practice displays (leg) when the variation in treatment is on the example displays (Eeg). Two columns in Figure 12 have been added to indicate these common variations. Figure 12 indicates the treatments involved in each of the seven (7) investigations reviewed.

Figure 13 indicates the posttest performance resulting from each of the various treatments which were compared. Two studies (Merrill & Tennyson Note 6; Tennyson, Steve, & Boutwell, 1975) compared example (Eeg) treatments with and without attribute isolation added. The Merrill and Tennyson study included three variations: example alone (Eeg), rule plus example (EG + Eeg), and rule plus elaboration of the rule, which consisted of further definition of the component concepts in the rule, plus example (EG + elaboration + Eeg). Except for one comparison (EG + Eeg) the addition of attribute isolation to the example displays resulted in superior posttest performance. Both studies involved concept classification. No studies were identified which used example displays with algorithmic elaboration to teach rule using.

Five studies (Merrill, 1970; Merrill, Barton, & Wood, 1970; Merrill & Stolurow, 1966; Osguthorpe, 1975; Tennyson, Steve, & Boutwell, 1975) compared practice (leg) treatments with and without algorithmic feedback following a student's response. It appears that when given a rather elaborate treatment consisting of elaborated rule displays (EG + elaboration + leg) and/or a number of example displays (EG + Eeg + leg) in addition to practice displays that the addition of algorithmic feedback does not promote any additional increment in performance. However, when the basic strategy consists of practice alone (leg) or unelaborated rules plus practice (EG + leg) that algorithmic feedback does facilitate posttest performance.

Two studies (Tennyson, Steve, & Boutwell, 1975; Young, 1972) compared concept classification practice (leg) treatments with and without attribute isolation feedback. Both showed that the addition of attribute isolation feedback facilitates posttest performance.

Four (4) of the studies collected time data (Merrill, 1970; Merrill, Barton, & Wood, 1970; Merrill & Stolurow, 1966; Tennyson, Steve, & Boutwell, 1975). Figure 14 indicates total time on

task required by each of the various treatments which were compared. The data indicate that even though attribute isolation or algorithmic information added up to 30% more instructional material that this additional material increased learning efficiency such that time on task was equal to (two studies), or less than (two studies), the time required to complete the treatment which did not have such mathemagenic information added. The Tennyson, Steve, and Boutwell (1975) study indicates that not only was learning more efficient but the time required to respond to test items was also more efficient.

Based on the investigations reviewed the part of the mathemagenic information hypothesis dealing with mathemagenic information prompting and feedback does seem to be supported for student performance and for efficiency. None of the studies reported affective data.

	Control	Eeg	Eeg + attribute isolation prompting	Eeg + algorithmic prompting	leg	leg + attribute isolation feedback	leg + algorithmic feedback	Treatments included EG	Treatments also included Eeg or leg	Task	Sample
Merrill (1970)					X	X		Yes	Yes	Rule Using	College
Merrill, Barton, Wood (1970)					X	X		Yes	Yes	Rule Using	College
Merrill and Stolurow (1966)					X	X		No	No	Rule Using	College
Merrill and Tennyson (Note 6)	X	X	X					No	No	Concept Classification	College
		X	X					Yes	No		
		X	X					Yes+	No		
Osguthorpe (1975)					X	X		No	No	Concept Classification	College
					X	X		Yes	No		
					X	X		Yes+	No		
Tennyson, Steve, Boutwell (1975) (Exp. 1)		X	X					Yes	No	Concept Classification	College
(Exp. 2)					X	X		Yes	No		
Young (1972)					X	X		Yes	No	Concept Classification	College

Figure 12. Investigations including treatment comparisons relevant to the Mathemagenic Information hypothesis.

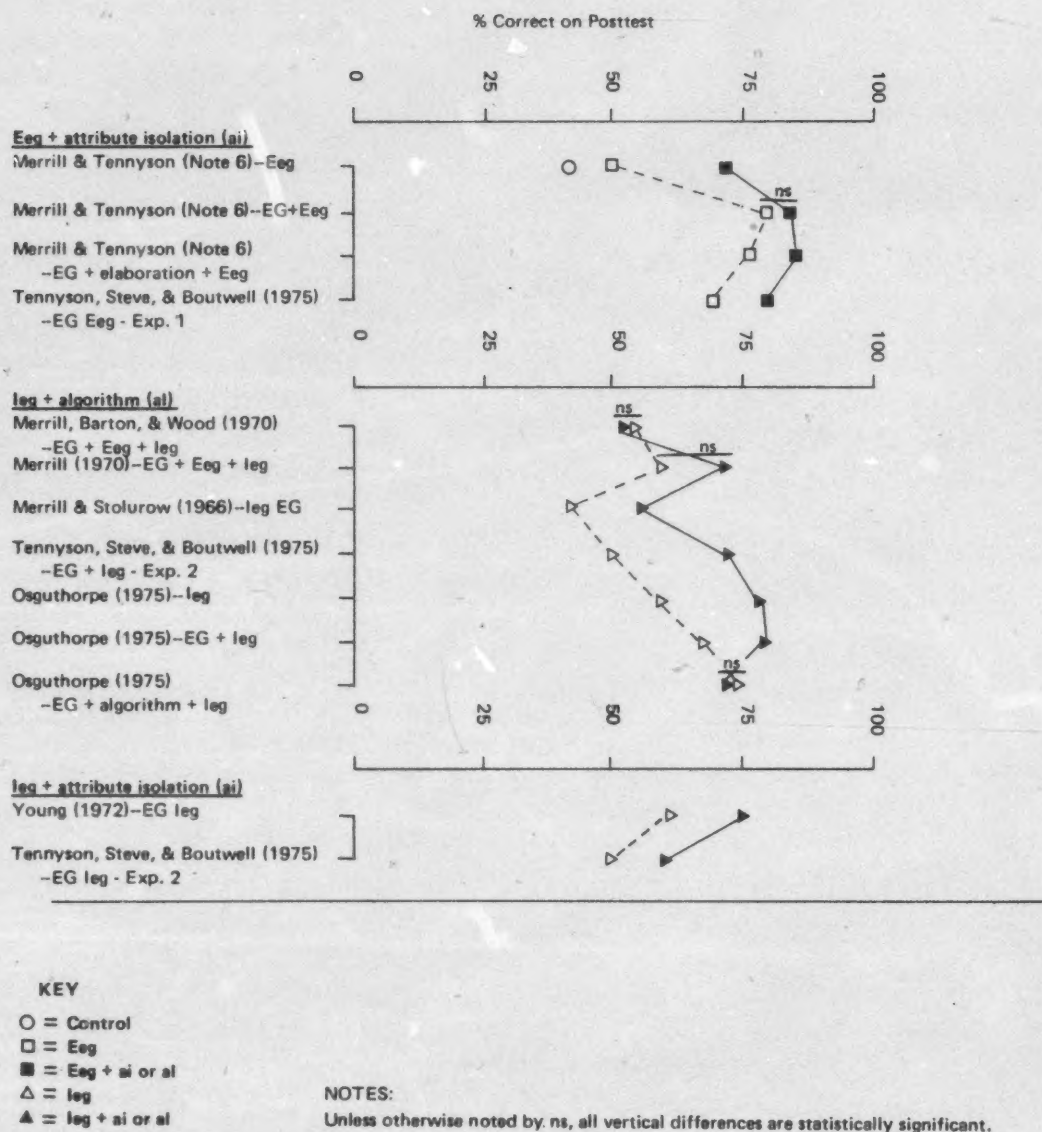


Figure 13. Student performance comparisons of Eeg or leg treatments plus attribute isolation or algorithmic mathemagenic information.

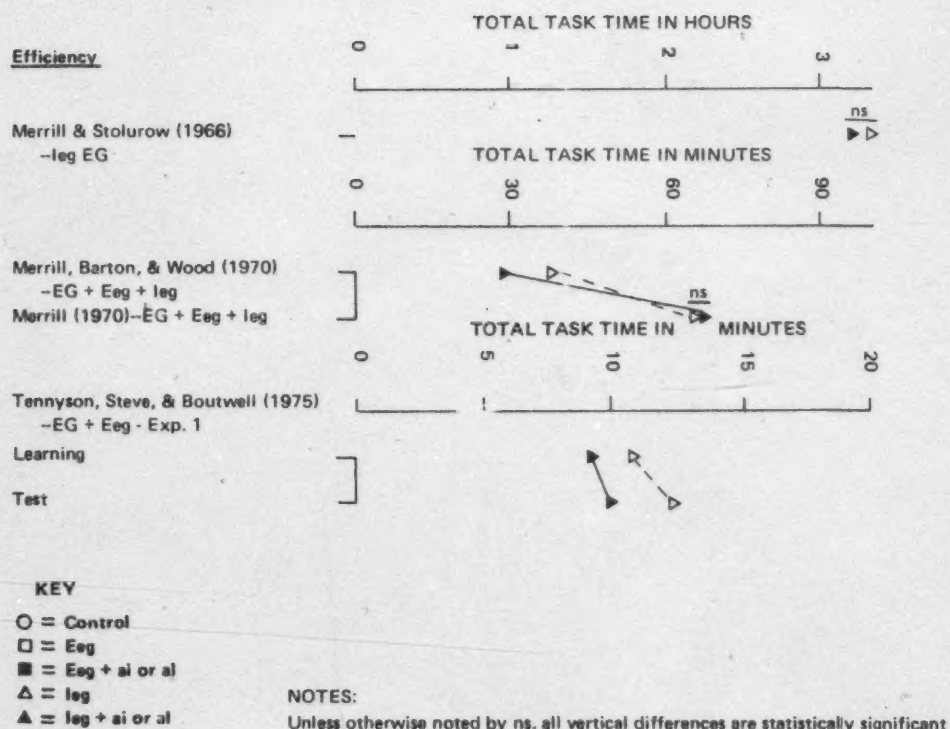


Figure 14. Time on task comparisons of Eeg or leg treatments plus attribute isolation or algorithmic mathemagenic information.

Attribute Matching

The attribute matching hypothesis states that example (Eeg) displays should include matched nonexamples. Practice (leg) displays should be randomly sequenced and unmatched to nonexamples. Six (6) studies have been identified which test some aspect of this proposition. The total proposition assumed that an adequate presentation involves both example and practice displays and that when both are included the matching should be on the examples but that on practice displays this source of help should be eliminated. None of the studies reviewed included both example and practice displays; hence, this interaction is not tested. Four (4) of the studies investigated attribute matching in a presentation which included only example displays, while three (3) of the studies looked at attribute matching in a presentation which included only practice displays. Some of the more obvious attribute isolation treatments are indicated across the top of Figure 15. A presentation consisting of examples only is indicated by the letters Eeg or leg while a presentation which also includes nonexamples is indicated by Eeg/eg or leg/eg. The matched or unmatched relationship between the examples and nonexamples is indicated in parentheses. Obviously many other treatment combinations are possible. Figure 15 also identifies the relevant treatments in the six (6) studies which are reviewed in relationship to this hypothesis.

Figure 16 illustrates the attribute isolation comparisons for each study. Four studies (Boutwell, Steve, & Tennyson, 1975; Merrill & Tennyson, Note 6; Merrill, Tennyson, & Woolley, 1972; Tennyson, 1973) demonstrated that when a presentation consists of example nonexample (Eeg/eg) displays a matched relationship results in superior performance to an unmatched or random relationship. In all of the studies the instances represented a range of instance difficulty and divergence variable attributes. In Tennyson (1973) one comparison used only easy instances. In this case there was no difference between the matched and unmatched conditions. The interaction illustrated is significant, indicating that the affect of matching is maximized when a range of difficulty is included.

Shumway (1971, 1974) demonstrated that when the presentation consists of practice displays, the inclusion of nonexamples (leg/eg) facilitates performance over the presentation of practice examples alone (leg). He did not include a matched relationship in his treatments. Boutwell, Steve and Tennyson (1975) showed that under three conditions of mathemagenic information a matched relationship between examples and nonexamples facilitates performance. It is interesting to note that in this study the same instances were used in each treatment, only the temporal and spacial relationship between specific instances was manipulated.

While the full implication of the attribute matching hypothesis was not tested by the investigations which were identified it is evident, from the data reported, that in a concept classification task when examples are matched to nonexamples, student performance will be facilitated.

	Control	Eeg	Eeg/eg (unmatched)	Eeg/eg (matched)	leg	leg/eg (unmatched)	leg/eg (matched)	Eeg leg	Eeg/eg leg (unmatched)	Eeg/eg leg (matched)	Eeg leg/eg (unmatched)	Eeg leg/eg (matched)	Eeg/eg leg/eg (unmatched)	Eeg/eg leg/eg (matched)	Treatments include EG	Task	Sample
Merrill & Tennyson (Note 6)			X	X											Yes	Concept Classification	College
Shumway (1971)					X	X									Yes	Concept Classification	College
Shumway (1974)					X	X									Yes	Concept Classification	College
Tennyson (1973)			X	X											Yes	Concept	College
			X	X											Yes	Classification	
Tennyson, Woolley, & Merrill (1972)			X	X											Yes	Concept Classification	College
Tennyson, Steve, & Boutwell (1975)			X	X											Yes	Concept	College
Exp. 1			X	X											Yes	Classification	
Exp. 2					X	X									Yes	Concept	College
					X	X									Yes	Classification	

Figure 15. Investigations including treatment comparisons relevant to the attribute matching hypothesis.

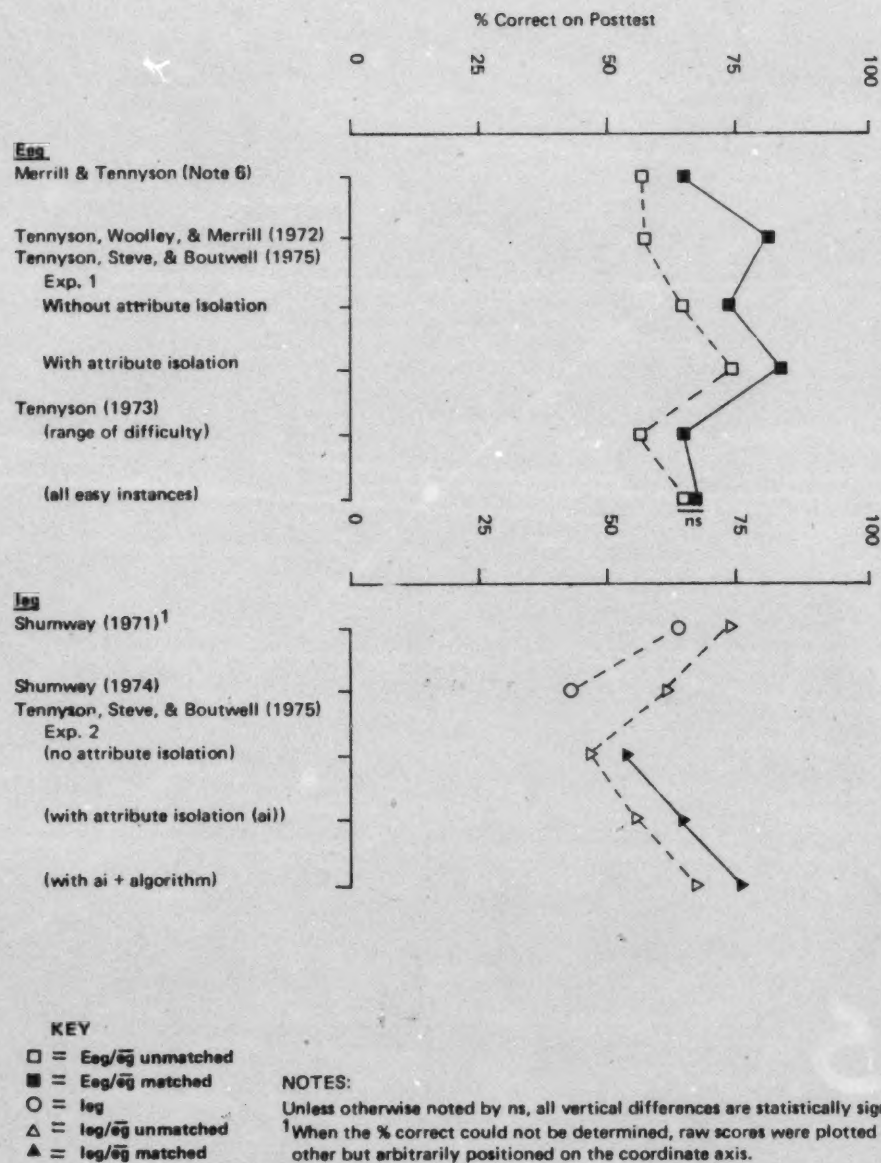


Figure 16. Comparisons of Eeg or leg displays with and without attribute matching.

Instance Sampling

The instance sampling hypothesis states that in both example (Eeg) and practice (leg) presentations the individual displays should be divergent on variable attributes, should range in difficulty, and/or should include a variety of representation forms. Four (4) studies included treatments in which variable attribute divergence versus convergence could be compared in situations where other variables are controlled. Three of the studies involved presentations of example displays (Eeg) only rather than practice displays (leg). One study involved practice displays (leg) on a rule using task. Three (3) of these studies also included treatments in which a range of instance difficulty could be compared with a presentation consisting of all easy instances. All of these treatments involved example displays (Eeg). No unconfounded treatments were identified which allowed a comparison of all hard instances to either a range of difficulty or to all easy instances. We were unable to identify any studies which investigated a variety of representation forms versus a single form of representation. Figure 17a indicates some of the possible divergent versus convergent treatments across the top. Figure 17b identifies some of the possible difficulty treatments across the top. The treatments included in the various studies are indicated in the figures.

Based on the four (4) comparisons of instance divergence versus convergence in Eeg presentations it is evident from Figure 18 that there was no posttest performance difference. All of the treatments involved a range of difficulty and did not include any matched relationships. In addition to correct classification, however, each of these studies looked at the classification errors of overgeneralization, undergeneralization, and misconception. Overgeneralization occurs when a student incorrectly identifies nonexamples as examples. Undergeneralization occurs when a student incorrectly identifies some examples as nonexamples. A misconception occurs when a student incorrectly assumes that a particular variable attribute is relevant and thus incorrectly identifies examples, which do not have this attribute, as nonexamples and incorrectly identifies nonexamples, which do have this attribute, as examples. In each of the comparisons, except the one which did not include nonexamples (Tennyson, 1973), the divergent treatments made significantly more misconception errors than the divergent treatments. Apparently, when used in unmatched example/nonexample presentations, divergence does not increase the total number of correct responses but it does affect the kind of errors that students make. Divergence probably interacts with matching. In these studies the best treatment involved divergence, matching and a range of difficulty. They did not, however, include a matched convergent group so a comparison of divergence versus convergence within matched conditions was not available.

In a rule using task using all practice displays Traub (1966) found that a divergent set of instances facilitated posttest performance. It was not possible to determine matched or unmatched relationships from Traub's report.

Figure 18 illustrates that when examples are matched to nonexamples students receiving instances which range from easy to hard perform better than students who receive only easy instances. In every case these studies also found that students in the all-easy-instance treatments made significantly more undergeneralization errors than those students who received a range of instance difficulty.

Based on these data the instance sampling hypothesis has received only partial support. The studies reviewed seem to indicate that when used with unmatched examples and nonexamples instance divergence does not significantly improve posttest performance but it does affect the kind of errors a student makes. Before one would be willing to conclude nonsupport for the divergence hypothesis, however, it would be desirable to more fully explore its interaction with the variables of matching and instance difficulty. The instance difficulty part of the hypothesis is supported within conditions of matching. The variety-of-representation part of the hypothesis was not tested by those studies which were reviewed.

	Control	Eeg → eg convergent	Eeg → eg divergent	leg → eg convergent	leg → eg divergent	Eeg (convergent) leg (convergent)	Eeg (divergent) leg (convergent)	Eeg (convergent) leg (divergent)	Eeg (divergent) leg (divergent)	Treatments include EG	Task	Sample
Merrill & Tennyson (Note 6)		X	X							Yes	Concept Classification	College
Tennyson (1973)		X	X							Yes	Concept Classification	College
Tennyson, Woolley, & Merrill (1972)		X	X							Yes	Concept Classification	College
Traub (1966)				X	X					Yes	Rule Using	11-12 years

Figure 17a. Investigations including treatment comparisons relevant to the instance sampling hypothesis--divergence.

	Control	Eeg (easy)	Eeg (hard)	Eeg (range)	leg (easy)	leg (hard)	leg (range)	Eeg (easy) leg (easy)	Eeg (range) leg (easy)	Eeg (hard) leg (easy)	(etc.)	Treatments include EG	Task	Sample
Merrill & Tennyson (Note 6)		X		X								Yes	Concept Classification	College
Tennyson (1973)		X		X								Yes	Concept Classification	College
Tennyson, Woolley, & Merrill (1972)		X		X								Yes	Concept Classification	College

Figure 17b. Instance sampling hypothesis--difficulty.

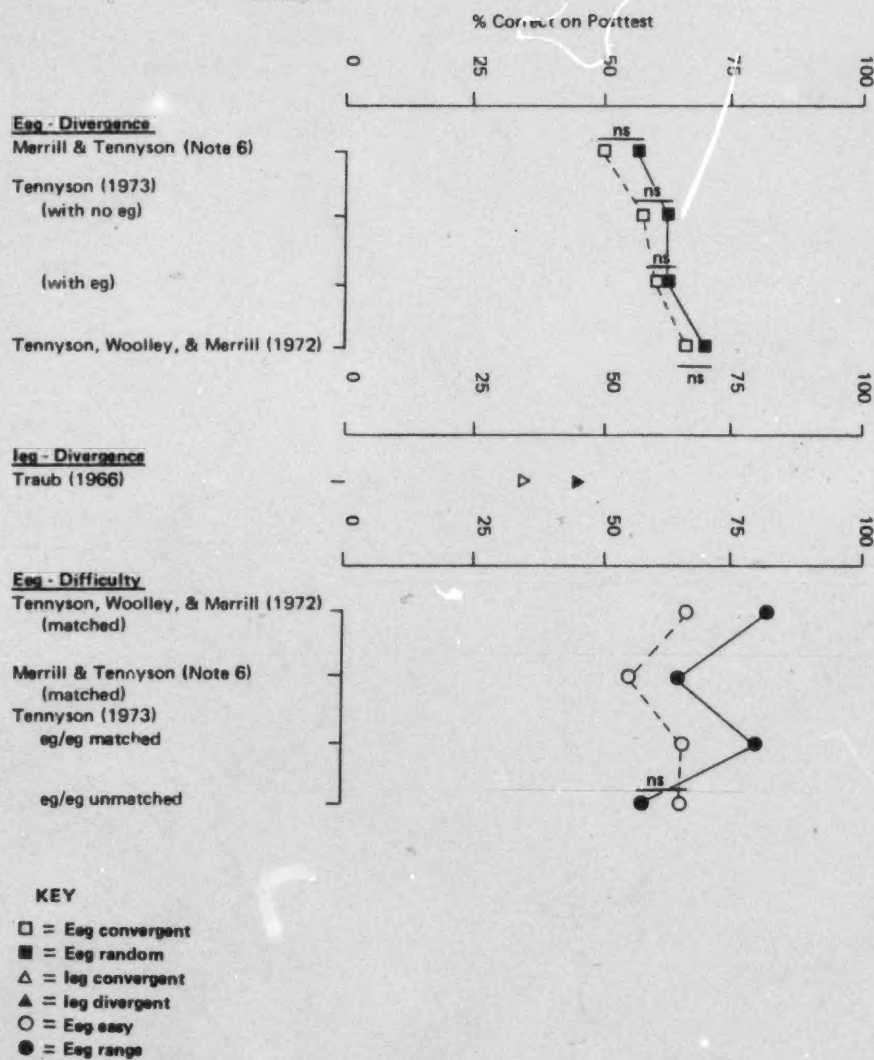


Figure 18. Comparisons of Eeg or leg displays where subsequent instances are divergent and convergent and where instances range in difficulty and are all easy.

CONCLUSIONS AND RECOMMENDATIONS

The Instructional Strategy Diagnostic Profile is based on eight propositions which prescribe parameter values for the inclusion, selection, sequence, and relationships between primary presentation forms for a segment of instruction. This review reported treatment data directly relevant to various aspects of six of these propositions. In every case the available data supported some aspect of the proposition. While some of the comparisons did not demonstrate significant differences, no contradictory data were identified. While considerable additional work needs to be done, the primary conclusion of this review is that the Instructional Strategy Diagnostic Profile has received sufficient support to justify its confident use to evaluate existing instructional products or to guide the design of new products.

Two of the propositions, the isolation and learner control propositions, were not tested at all by any of the studies the reviewers were able to identify. (1) The first recommendation for further research is to conduct a series of carefully controlled investigations exploring the various treatment conditions suggested by these hypotheses. In the meantime, the application of those ISDP guidelines, which are based on these hypotheses can be based only on a belief in the propositions rather than on experimental data.

Most of the studies reviewed tested only part of the propositions stated. Further recommendations suggest studies which would extend that which has been done to more adequately test all aspects of the various propositions.

(2) While the data do seem to support the proposition that all three primary presentation forms should be used for a given presentation segment, additional work needs to be done in comparing various combinations of forms, especially those involving practice and those involving all forms.

(3) The sequence of primary presentation forms has been investigated with only rule practice (EG-leg) and practice rule (leg-EG) sequences. Additional work needs to be done in comparing sequences involving example (Eeg) displays and sequences involving all three forms.

(4) While there was some support for representing the generality in other than verbal form, considerable additional work is desirable here. Further taxonomic categories for types of representation and their interrelationships should be identified. Additional empirical studies investigating the relative value of these various techniques should also be conducted. The use of algorithmic representation, its limits and disadvantages, as well as its advantages, has received only preliminary attention. Additional taxonomic development, as well as experimental investigations, should be conducted in relationship to this hypothesis.

(5) The use of mathemagenic information, especially attribute isolation and algorithmic feedback seems to have a powerful facilitating affect on performance. However, the role of mathemagenic information, especially in complex treatments involving rule, example, and practice displays, needs considerably more study. The interaction of mathemagenic information with parameter values on other variables is hinted at in the data reported. These relationships need more systematic exploration.

(6) Attribute matching is almost never used in the design of instructional products yet the data indicate that this variable is of considerable value. However, all of the data identified to date have been gathered in situations where either example (Eeg) or practice (leg) displays are used alone. The

role of attribute matching in some of the more complex treatments identified in Figure 15 should be studied. Attribute matching seems to interact with mathemagenic information and with variable attribute divergence. The nature of these interactions should also be systematically explored.

(7) Variable attribute divergence was not found to be a facilitating variable in the limited situations in which it was investigated. However, the data do seem to hint at some strong interactive effects of this variable with variables such as attribute matching, mathemagenic information, and instance difficulty. The nature of these interactions should be explored.

While a range of instance difficulty was found to be more effective than all easy instances there are numerous other relationships of instance difficulty and other variables which need systematic exploration.

Representation variety seems logically desirable. Studies isolating this variable and exploring its interaction with the other variables mentioned should also be conducted.

(8) The time relationships reported in conjunction with the mathemagenic information hypothesis are most interesting. They do demonstrate, not only increased effectiveness, but increased efficiency. Efficiency outcomes should be explored in relationship to all of the propositions.

(9) Asking students how they feel or how they liked something has been out of vogue during the past several decades. However, it should be evident that long range interest in an area of study is very dependent on the emotional appeal of the presentation. Such attitude data are needed in relationship to all of the propositions.

(10) Some of the propositions have been tested almost exclusively in concept classification task situations while others are used primarily for rule using tasks. A more systematic exploration of these propositions in relationship to these different task outcomes is desirable to identify qualifications which should be applied as a result of the type of task involved.

This review has demonstrated that it is possible to identify educational hypotheses that do make a difference. However, the task of clarifying, refining, and extending these propositions has only just begun. Hundreds of additional studies are needed to clarify, limit and extend our understanding and our ability to develop more effective instructional strategies.

REFERENCE NOTES

1. Merrill, M.D., & Wood, N.D. Instructional strategies: A preliminary taxonomy (Rev. ed.). (Courseware Tech. Rep. 1R). Orem, Utah: Courseware, Inc., 1975.
2. Merrill, M.D., & Wood, N.D. The instructional strategy diagnostic profile. Book in preparation, 1976.
3. Smith, P.E. The influence of four instructional components on concept acquisition. Paper presented at the meeting of the American Educational Research Association, Washington, D.C., 1975.
4. Merrill, M.D., & Tennyson, R.D. Attribute prompting variables in learning classroom concepts. (IR&D Working Paper No. 28). Provo, Utah: Brigham Young University Press, 1971. (USOE Contract O-H-014.)
5. Kalisch, S.J., Merrill, P.F., Towle, N.J., & Steve, M.H. The effects of the availability of objectives and/or rules in a learner-controlled computer based task. Paper presented at the meeting of the American Educational Research Association, New Orleans, March 1973.
6. Merrill, M.D., & Tennyson, R.D. Concept classification and classification errors as a function of relationships between examples and nonexamples. Manuscript submitted for publication, 1976.

REFERENCES

- Anderson, R.C., & Kulhavy, R.W. Learning concepts from definitions. American Educational Research Journal, 1972, 9, 385-390.
- Austin, J.D. An experimental study of the effects of three instructional methods in basic probability and statistics. Journal for Research in Mathematics Education, 1974, 5, 146-154.
- Cartwright, G.P. The relationship between sequences of instruction and mental abilities of retarded children. American Educational Research Journal, 1971, 8, 143-150.
- Cole, H., & Raven, R. Principle learning as a function of instruction on excluding irrelevant variables. Journal of Research in Science Teaching, 1969, 6, 234-241.
- Danks, J.H., & Gans, D.L. Acquisition and utilization of a rule structure. Journal of Experimental Psychology, 1975, 104, 201-208.
- Deno, S.L., Jenkins, J.R., & Marsey, J. Transfer variables and sequence effects in subject-matter learning. Journal of Educational Psychology, 1971, 62, 365-370.
- Dossey, J.A., & Henderson, K.B. The relative effectiveness of four strategies for teaching disjunctive concepts in mathematics. Journal for Research in Mathematics Education, 1974, 5, 6-19.
- Dwyer, F.M., Jr. Effect of visual stimuli on varied learning objectives. Perceptual and Motor Skills, 1968, 72, 1067-1070.
- Gilman, D.A. The effects of feedback on learner's certainty of response and attitude toward instruction in a computer assisted instruction program for teaching science concepts. Journal of Research in Science Teaching, 1969, 6, 171-184.
- Guthrie, J.T. Expository instruction versus a discovery method. Journal of Educational Psychology, 1967, 58, 45-49.
- Guthrie, J.T., & Baldwin, T.L. Effects of discrimination, grammatical rules, and application of rules on the acquisition of grammatical concepts. Journal of Educational Psychology, 1970, 61, 358-364.
- Hammond, J., & Raven, R. The effects of a structured learning sequence on the achievement on compensatory tasks. Journal of Research in Science Teaching, 1973, 10, 257-262.
- Holliday, W.G. The effects of verbal and adjunct pictorial-verbal information in science instruction. Journal of Research in Science Teaching, 1975, 12 (1), 77-84.
- Johnson, R.B. The effects of prompting, practice and feedback in programmed videotape. American Educational Research Journal, 1968, 5, 73-79.
- Klausmeier, H.J., & Feldman, K.V. Effects of a definition and varying number of examples and non-examples on concept attainment. Journal of Educational Psychology, 1975, 67, 174-178.

- Klum, G., Omari, I., Lewis, J.F., & Cook, H. The effectiveness of textbooks, student generated, and pictorial versions of presenting mathematical problems in ninth grade algebra. Journal for Research in Mathematics Education, 1974, 5, 28-35.
- Koran, M.L. Differential response to inductive and deductive instructional procedures. Journal of Educational Psychology, 1971, 62, 300-307.
- Krumboltz, J.D., & Yabroff, W.W. The comparative effects of inductive and deductive sequences in programmed instruction. American Educational Research Journal, 1965, 2, 223-234.
- Merrill, M.D. Specific review versus repeated presentation in a programmed imaginary science. Journal of Educational Psychology, 1970, 61, 392-399.
- Merrill, M.D. Learner control: Beyond aptitude-treatment interactions. A V Communication Review, 1975, 23, 217-226.
- Merrill, M.D., Barton, K., & Wood, L.E. Specific review in learning a hierarchical imaginary science. Journal of Educational Psychology, 1970, 61, 102-109.
- Merrill, M.D., & Boutwell, R.C. Instructional development: Methodology and research. In F.N. Kerlinger (Ed.), Review of research in education (Vol. 1). Itasca, N.Y.: Peacock, 1973.
- Merrill, M.D., & Stolurow, L.M. Hierarchical preview vs. problem oriented review in learning an imaginary science. American Educational Research Journal, 1966, 3, 251-261.
- Merrill, M.D., & Wood, N.D. Instructional strategies: A preliminary taxonomy. Columbus, Ohio: Ohio State University, 1974. (ERIC Document Reproduction Service No. SE 018-771.)
- Merrill, P.F. Effects of the availability of objectives and/or rules on the learning process. Journal of Educational Psychology, 1974, 66, 534-539.
- Osguthorpe, R.T. The effects of definition and instance presentation on the acquisition of an ordered classification rule. Unpublished doctoral dissertation, Brigham Young University, August 1975.
- Payne, D.A., & Krathwohl, D.R. The effect of sequence on programmed instruction. American Educational Research Journal, 1967, 4, 125-132.
- Pyatte, J.A. Some effects of unit structure on achievement and transfer. American Educational Research Journal, 1969, 6, 247-260.
- Raven, R.J. The effects of a structured learning sequence on second and third grade children's classification achievement. Journal of Research in Science Teaching, 1970, 7, 153-160.
- Scandura, J.M. Role of higher order rules in problem solving. Journal of Experimental Psychology, 1974, 102, 984-991.
- Scandura, J.M., Woodward, E., & Lee, F. Rule generality and consistency in mathematics learning. American Educational Research Journal, 1967, 4, 303-319.

- Shumway, R.J. Negative instances and mathematical concept formation: A preliminary study. Journal for Research in Mathematics Education, 1971, 2, 218-227.
- Shumway, R.J. Negative instances in mathematical concept acquisition: Transfer effects between the concepts of commutativity and associativity. Journal for Research in Mathematics Education, 1974, 5, 197-211.
- Snow, R.E. Theory construction for research on teaching. In M.W. Robert (Ed.), Second Handbook of Research on Teaching, Chicago: Rand McNally, 1973.
- Stern, C., & Keislar, E.R. Acquisition of problem solving strategies by young children and its relation to mental age. American Educational Research Journal, 1967, 4, 1-12.
- Tanner, R.T. Expository-deductive versus discovery-inductive programming of physical science principles. Journal of Research in Science Teaching, 1969, 6, 136-142.
- Tennyson, R.D. Effect of negative instances in concept acquisition using a verbal-learning task. Journal of Educational Psychology, 1973, 64, 247-260.
- Tennyson, R.D., Steve, M.W., & Boutwell, R.C. Instance sequence and analysis of instance attribute representation in concept acquisition. Journal of Educational Psychology, 1975, 67, 821-827.
- Tennyson, R.D., Woolley, R.F., & Merrill, M.D. Exemplar and nonexemplar variables which produce correct concept classification behavior and specified classification errors. Journal of Educational Psychology, 1972, 63, 144-152.
- Traub, R.E. Importance of problem heterogeneity to programmed instruction. Journal of Educational Psychology, 1966, 57, 54-60.
- Weisberg, J.S. The use of visual advance organizers for learning earth science concepts. Journal of Research in Science Teaching, 1970, 7, 161-165.
- Williams, J.P., & Levy, E.I. Retention of introductory and review programs as a function of response mode. American Educational Research Journal, 1964, 1, 211-218.
- Worthen, B.R. Discovery and expository task presentation in elementary mathematics. Journal of Educational Psychology Monograph Supplement, 1968, 59, 1-13.
- Yelon, S., & Schmidt, W.H. The effect of objectives and instructions on the learning of a complex cognitive task. Journal of Experimental Education, 1973, 41, 91-96.
- Young, J.I. The effects of review techniques and instance presentation on concept learning tasks. Unpublished doctoral dissertation, Brigham Young University, May 1972.